

Gravitational Lens in Abell 2218

HST • WFPC2

PF95-14 • ST ScI OPO • April 5, 1995 • W. Couch (UNSW), NASA

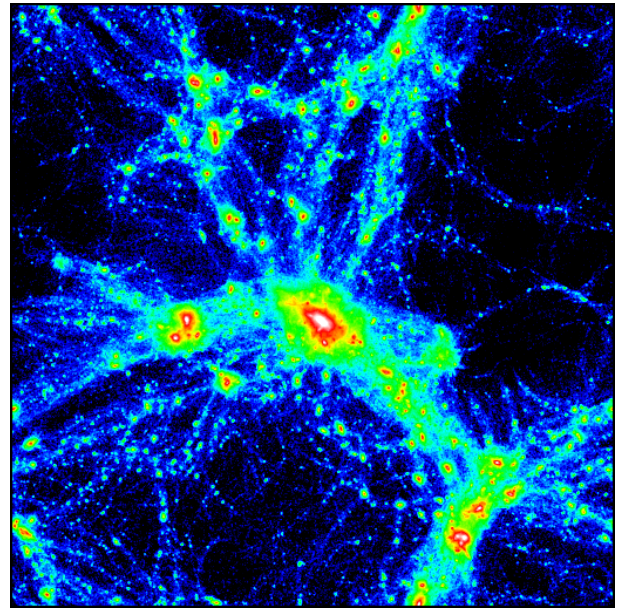
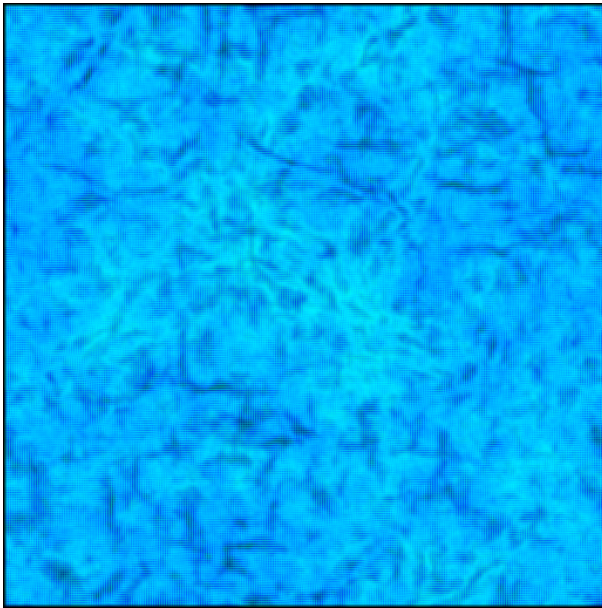
N-body codes:

- Cube with periodic boundary conditions; comoving coordinates
- Sample continuous distribution with N particles
- Leapfrog:

$$\mathbf{x}_i^{n+1/2} = \mathbf{x}_i^{n-1/2} + \Delta t \mathbf{v}_i^n + O(\Delta t^3)$$

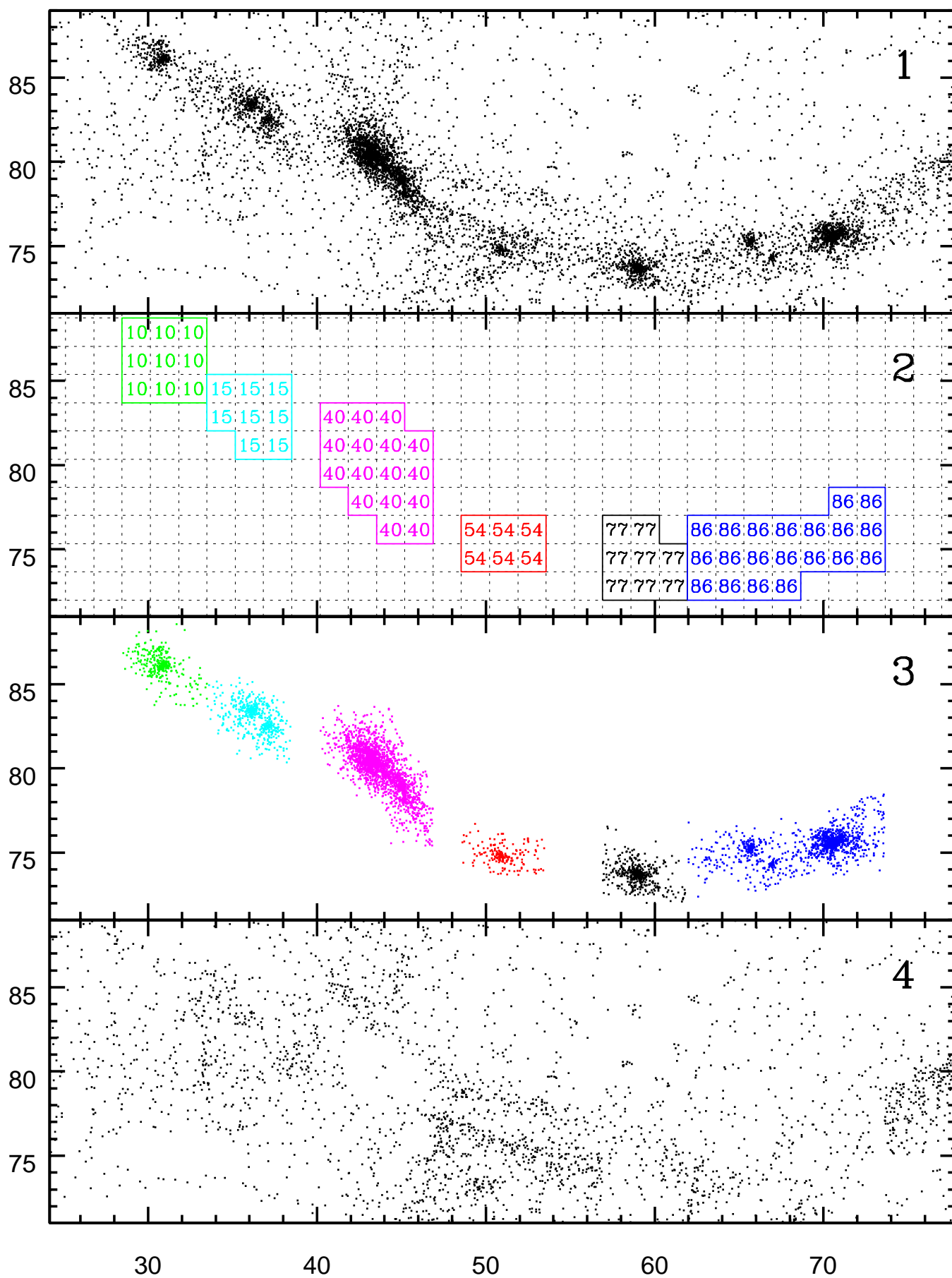
$$\mathbf{v}_i^{n+1} = \mathbf{v}_i^n + \Delta t \mathbf{a}_i^{n+1/2} + O(\Delta t^3)$$

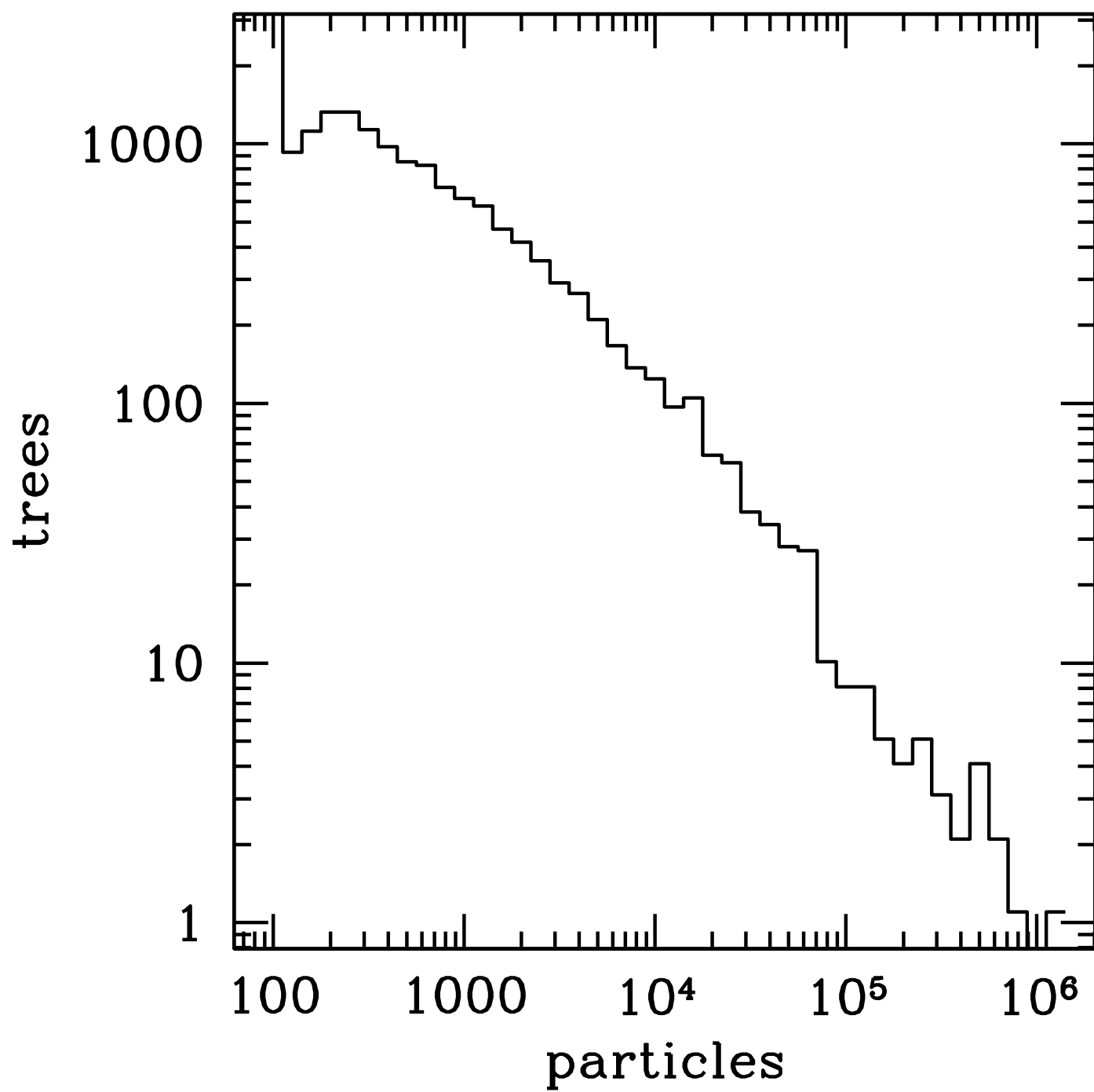
$$\mathbf{a} = \nabla \Phi(\mathbf{x} = \mathbf{x}_i), \quad \nabla^2 \Phi = 4\pi G \rho$$



Difficulties:

- Gravity is long range
- Highly inhomogeneous particle distribution
- Want large box (~ 100 Mpc) but high resolution (~ 1 kpc)





TPM algorithm:

Split long-range and short-range forces

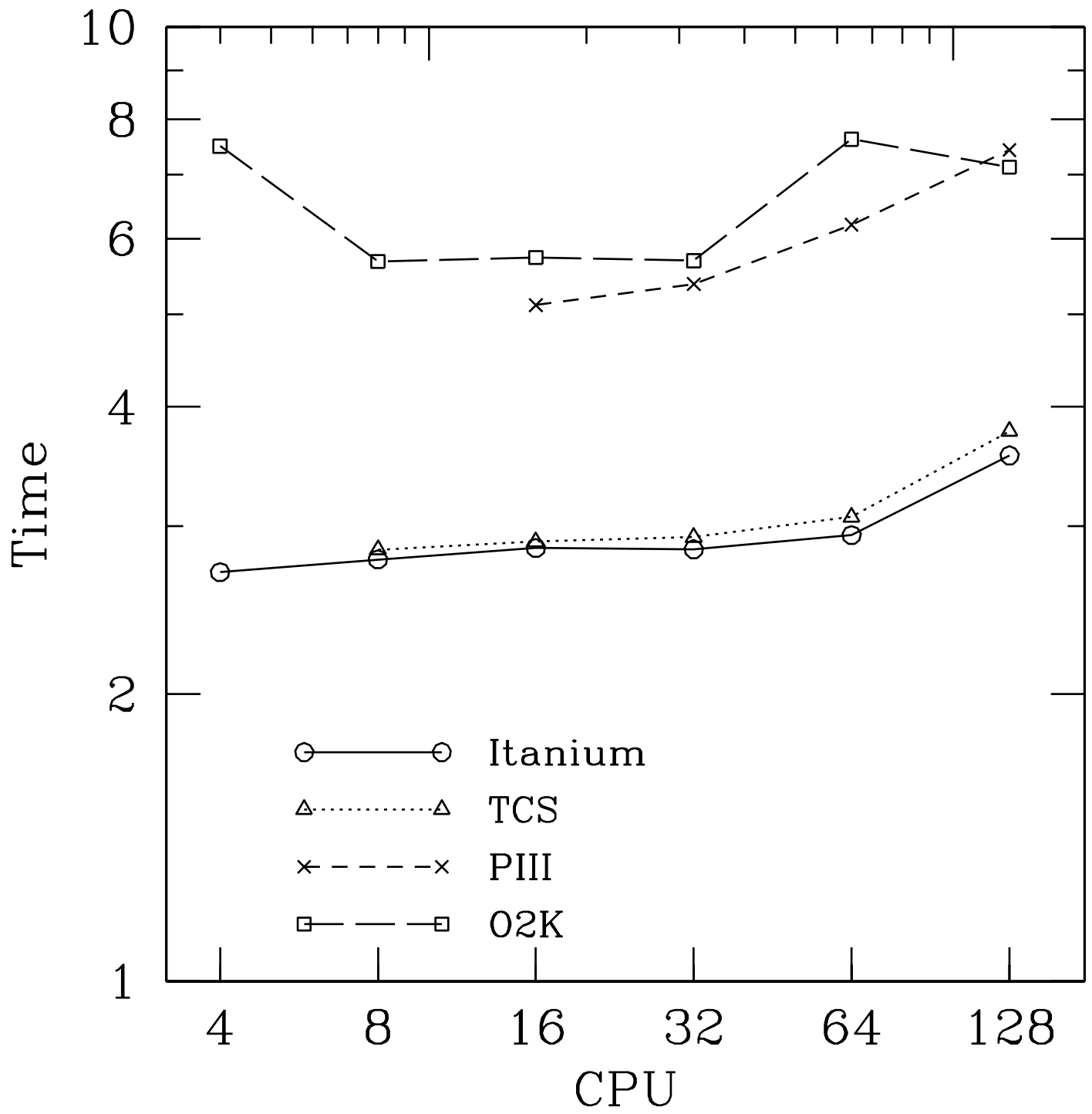
- Compute Φ on Eulerian grid
 - Particle-Mesh (PM) method:
 - solve Poisson's equation in Fourier space.
- Domain decomposition:
 - pick particles requiring higher resolution,
 - divide them into T isolated groups.
- For each group:
 - adjust PM potential \implies tidal field;
 - integrate forward with tree code
 - (using shorter time step if needed).
- Step PM particles

One big problem now T smaller problems, run in parallel

Load balancing:

- estimate work from sizes of trees; split evenly
- if node finishes early, request unfinished tree from others
- let two or more nodes share a tree

$N=256^3$ LCDM $z=0.1$



Issues for Large ($N=1024^3$) runs:

- IO: $\sim 36\text{Gb}$ per checkpoint
- Dealing with large data set, e.g.:
 - Ray tracing for gravitational lensing or SZ
 - $\implies \rho, < v >$ at given point.
 - Find gravitationally bound objects and their properties.
 - Same set of particles at different redshifts.
 - Visualizing.
- FFT library:
 - 1-D and 3-D serial
 - 3-D parallel?
- Single tree parallelism (need only up to ~ 8 CPU)
- Serial performance of tree
- <http://astro.princeton.edu/~bode/expedition>